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Securing Guarantees:
How Nuclear Proliferation Can Strengthen Great Power Commitments

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Securing Guarantees:
How Nuclear Proliferation Can Strengthen Great Power Commitments

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Securing Guarantees:
How Nuclear Proliferation Can Strengthen Great Power Commitments

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The number of states with nuclear weapons has grown at a much slower rate than many predicted during the early years of the Cold War. Yet the reasons for this slow rate of proliferation are not well understood. What is maintaining the (predominantly non-nuclear) status quo? Other work takes external threats and the credibility of security guarantees as given, but I show how nuclear proliferation can shape and be shaped by both. This approach allows me to show how the decisions of proliferators, their allies, and their adversaries are intertwined. This leads to a previously unexplored effect of proliferation: in addition to the defensive and deterrent capability of nuclear weapons, nuclear possession can also cause great powers to tighten their alliance commitments. Great powers therefore have incentives to dissuade nuclear pursuit through threats of sanctions when they are capable of imposing them and through heightened security guarantees when they cannot.

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Chapter 1

Introduction

Membership in the nuclear club has grown more slowly than many expected during the early years of the Cold War. Although a handful of countries have acquired nuclear weapons capability, many others that were expected to go nuclear have not. Within this group of non-nuclear states, however, we still see significant variation in the levels of nuclear development and circumstances surrounding their decisions. Several states, such as Japan, Germany, and Brazil, have achieved a level of latent capability that would enable them to achieve a working weapon in a relatively short period of time if they so chose, yet have never expressly pursued a weapons program. Meanwhile others, such as South Korea, Taiwan, and Libya, have begun the active development of nuclear weapons, only to be pressured into abandoning their programs. Still others, including North Korea, South Africa, and Israel, have gone as far as developing working weapons over the objections of other states. Thus there is significant variation not only in the decisions of states to pursue nuclear weapons, but also in the willingness and ability of others to prevent this acquisition. In order to understand the decisions of both would-be proliferators and those who would stop them, we must understand the influence of the circumstances underlying these decisions and how changes in them could lead states to make different decisions, opting for nuclear pursuit rather than restraint.

Existing literature on proliferation tends to consider either the motivations of the would-be nuclear power or of existing major powers independently, without allowing for interaction between the two. Additionally, few studies consider threatening states as independent actors in this process.[1] However, when considering the incentives of proliferators, allies, and adversaries

[1] Debs and Monteiro (2016) is a notable exception here.

together, I find that proliferation by a subordinate state can sometimes make a great power *more* likely to intervene on the subordinate's behalf, transforming a previously incredible defensive commitment into a credible one. Therefore, some states may pursue nuclear weapons not only to provide for their own security, but also to enhance a great power's commitment to that security. Thus in addition to their defensive and deterrent potential, nuclear weapons may also have the previously unexamined benefit of drawing great power allies closer. Further, a credible defensive commitment cannot be made incredible through nuclear acquisition, meaning proliferators need not fear that they will be abandoned *after* achieving nuclear status. This possibility arises from a preference on the part of great powers: all else equal, I posit that great powers prefer that if their allies are defeated militarily, those allies do not possess nuclear weapons. That is, a loss by a nuclear ally is costlier for a great power than a loss by a non-nuclear one.

Great powers, in turn, have incentives to prevent proliferation when undertaken by states in volatile relationships. In these instances, the threat of economic or military sanctions can sometimes force a subordinate state to abandon its nuclear ambitions. Yet if a great power is unable to make such sanctions sufficiently costly, it can find itself entrapped by an ally's acquisition of a nuclear weapon. In such cases, strengthening a security guarantee can become an attractive option for preventing proliferation. Thus both nuclear proliferation itself and the threat thereof can have the effect of drawing great power allies closer to their protégés and tightening hierarchies in the international system. Proliferation decisions are not one-sided, but rather depend upon a state's existing relationships and position in the international system, and such decisions can in turn alter this structure.

Chapter 2

A Strategic Theory of Proliferation

Despite the wealth of empirical studies on the subject of nuclear weapons, we lack an organizing framework within which to understand these often disparate findings. Although it accounts for strategic interaction between proliferating states, great powers, and adversaries, the most comprehensive model of nuclear proliferation to date (Debs and Monteiro 2016) cannot explain why, despite the threats of abandonment often leveled at states attempting to build their own nuclear arsenals, we sometimes see great powers' commitments actually *increase* upon nuclear acquisition. The most notable instance is Israel, but there is also evidence that South Africa's nuclear strategy was predicated upon provoking the US to intervene in the region by quietly revealing its nuclear capability if necessary to draw the US in (Reiss 1995).

2.1 Motivation for Nuclear Pursuit

Table 2.1 shows a partial list of states whose proliferation paths are of interest. The first column lists observable instances of proliferation — states that acquired nuclear weapons over the objections of great powers.[1] The second column represents states that explicitly expressed interest in nuclear acquisition (sometimes to the point of beginning a weapons program) or have the latent capability to develop a weapon but have as yet not chosen to do so. These are "non-observations" – instances where proliferation has *not* occurred but could reasonably have been expected. The third column includes observations where states' programs have been militarily stopped (Syria and Iraq) or whose progress has been significantly slowed such that a working weapon has not

[1]Note that this list includes *all* states that acquired nuclear weapons after the US, USSR, and UK, which were the first three to do so.

yet been acquired (Iran), and the fourth column represents instances of explicit renunciation of existing weapons.[2]

Table 2.1: Nuclear Status

Acquired	**Interested or Capable**	**Stopped**	**Renounced**
China	Germany	Syria	South Africa
France	South Korea	Iraq	Ukraine
India	Taiwan	Iran	
Pakistan	Libya		
South Africa	Japan		
North Korea	Brazil		
Israel			

I suggest that the differences among these columns can be represented by differences in the ability of proliferating states to develop weapons programs (i.e. to withstand costly sanctions) and their motivation to do so, shaped by 1) the presence or absence of credible great power defensive commitments, and 2) the nature of the external threat.[3] For instance, France had a high level of autonomy when faced with an incredible commitment from the US and a deterrable adversary (the USSR) following World War II and thus was able to develop a nuclear program.[4] Yet at the same time, West Germany, although facing the same threat and covered by the same questionable US umbrella, was constrained by the hierarchical nature of its relationship with the US, causing different observable outcomes. In the category of states without nuclear weapons, we also see variation. Although South Korea was faced with a significant threat from North Korea following the Korean War, it relied too heavily on the United States for its security to complete its weapons program. The threatened US withdrawal of troops from the peninsula would have been too costly.

[2]I include Ukraine here but not Belarus or Kazakhstan due to evidence that the former possessed some (albeit a disputed) level of control over their inherited weapons where the latter two did not.

[3]This corresponds roughly with the *willingness and opportunity* framing used by both Debs and Monteiro (2016) and Jo and Gartzke (2007) .

[4]I use the terms "autonomy" and "hierarchy" as antonyms throughout; states in relationships characterized by a high level of hierarchy have a low level autonomy, and vice versa. "Hierarchy" is the overarching concept of interest.

Yet Japan, also in the non-nuclear column, possesses the autonomy to acquire nuclear weapons but also has a credible defensive commitment from the US, obviating the need to do so; its limits are self-imposed rather than external. Finally, states whose programs have been ended by force faced undeterrable threats and lacked both credible defensive commitments and the autonomy to withstand attacks on their developing programs.

The framework here explains variation not only among observably different outcomes, in which some states acquire nuclear weapons and others do not, but also among those cases in which the final proliferation decision is the same but the underlying circumstances are quite different. Consequently, it identifies when changes in these circumstances, such as shifts in security guarantees, may be expected to cause non-nuclear states to change course and begin down the road to proliferation and when such changes are unlikely to have such an effect. Critically, these circumstances can and do change. The recent electoral victories of Shinzo Abe's Liberal Democratic Party in Japan, for instance, have given him the two-thirds majority in both houses needed to pursue his visions of constitutional change, including rewriting Article 9 and potentially removing the institutional constraints on Japan's military. Further, Abe's appointment to the position of defense minister, Tomomi Inada, has openly considered the possibility of nuclear weapons, saying in 2011 that "Japan should consider possessing nuclear weapons as a national strategy in the long term."[5] Likewise, Russia's 2014 annexation of Crimea has caused some within Ukraine to doubt the wisdom of their decision to return to Russia the nuclear weapons inherited with the fall of the Soviet Union. According to Ukrainian MP Pavlo Rizanenko, "[T]here's a strong sentiment in Ukraine that we made a big mistake. In the future, no matter how the situation is resolved in Crimea, we need a much stronger Ukraine. If you have nuclear weapons people don't invade you."[6] Thus although the current state of the world includes few nuclear powers, it is critical to

[5]Okamura, Natsuki and Isamu Nikaido. "Defense chief Inada seen as possible spoiler of relations." *The Asahi Shimbun*, August 4, 2016, accessed March 15, 2017. `http://www.asahi.com/ajw/articles/AJ201608040051.html`.

[6]Zurcher, Anthony. "Ukraine's nuclear regret?" *BBC News*, March 20, 2014, accessed February 12, 2017, `http://www.bbc.com/news/blogs-echochambers-26676051`.

understand what is maintaining this status quo and what could upset it.

The status of nuclear weapons programs thus depends not only on whether states have the ability to acquire nuclear weapons, but also whether they have the motivation to do so. To answer the question of what motivates nuclear pursuit, we must consider the circumstances that might make such development attractive and feasible. I examine states' external threats, credible defensive guarantees, and hierarchical relationships in turn.

2.2 The Demand Side

2.2.1 External Threat

First, the level of external threat states face influences whether they have the motivation to build nuclear weapons. States with a high and persistent level of threat, such as those in enduring rivalries or with historically hostile neighbors, are more likely to find nuclear weapons attractive for their deterrent and defensive purposes than those lacking such an existential threat. For instance, Rajagopalan (2008) argues that the primary purpose of India's nuclear weapons is to deter China and Pakistan, both themselves nuclear, while the existential threat posed by India, with its superior conventional capability, motivates Pakistan. Thus, Powell's (2003) argument is applicable here; nuclear weapons may allow small states to deter major powers in issues where a small state is clearly more resolved than its opponent (such as issues of "regime survival"). This means that states facing threats to their survival should find nuclear weapons more useful than states taking offensive action, as the latter will find the potential for destruction an unacceptably high risk compared with their goals.

2.2.2 Credible Defensive Guarantees

Second, the degree to which states have credible defensive guarantees from great powers also influences their motivation. The presence of a credible great power commitment can make the costly process of nuclear weapons development less attractive; if states are secure in the knowledge that another will come to their defense, they are less likely to find nuclear weapons a necessary or

worthwhile investment. On the other hand, if allies fear that a great power is unlikely to defend them in the event of an attack, they may turn to other means to provide for their own defense. As Reiter (2014) and Lanoszka (2014) suggest, incredible security commitments can create a fear of abandonment. If the costs of defending a protégé are high, great powers have incentives to renege on their security commitments in the event of an attack, making them unreliable defenders. Knowing this, subordinate states may wish to pursue nuclear weapons in order to provide for their own defense. In some cases this will not be possible; some states will simply not have the resources to commit to the endeavor. This lack of resources has a constraining effect and helps explain why many states with incredible security commitments do not pursue nuclear weapons.

Thus countries like Japan or Germany, which have historically possessed highly credible defensive guarantees from the US,[7] may see no reason to shoulder the burden of a costly nuclear program despite threatening environments. Similarly, the integration of Canadian defense against the Soviet nuclear threat into the US defensive system clearly obviated the need for Canada to provide such a system for itself (Reynolds 2000). Although the empirical findings on security guarantees are mixed, Bleek and Lorber (2014) tackle these results and find that security guarantees make proliferation less likely, at all levels of the process, suggesting that the loss of such guarantees may make proliferation increasingly likely.

The question of the conditions under which leaders honor alliance commitments during war (Leeds 2003) can also be re-framed to ask under what conditions a great power would honor its explicit or implicit obligation to protect a protégé in the event of an attack on the latter. In particular, Leeds argues that abrogation is likely when the costs of violating the alliance agreement are low (as with major powers) or when significant changes in circumstances between alliance formation and invocation lead to the reevaluation of a state's interests (Leeds 2003). These conditions may be applied to the issue of when a great power's commitment to a smaller state's defense is in question; if a great power's costs of fighting in a conflict are high relative to whatever

[7]See Gavin (2012) for a discussion of US efforts to reassure West Germany that its defensive commitment was secure following World War II.

loss it would incur in the event of its partner's defeat in a war, it may have an incentive to abandon that partner.

2.3 The Supply Side

2.3.1 Hierarchy

Third, the level of hierarchy in which states exist, or the degree to which they are subordinate to another state and thus vulnerable to costly military or economic sanctions, influences their ability to acquire nuclear weapons. Even if states find nuclear possession attractive, they may be unable to develop a program to the point of a working weapon if another state is able to impose unacceptably high costs for doing so. For instance, the US threat to remove American troops from South Korea played a critical role in ending that country's covert nuclear weapons program upon its discovery.

Nuclear acquisition is an expensive process, and opposition by great powers can render it even more so. The desire to pursue nuclear weapons can therefore be tempered by the expectation that additional, external costs will be imposed during the process. For instance, great powers often play a critical role in bolstering the militaries of states within their spheres of influence, and the threat of losing this assistance may have a deterrent effect on proliferation. South Korea relied heavily on U.S. military and financial assistance, including the presence of U.S. troops, to ensure its security following the Korean War, placing it in a position where the threats of US withdrawal effectively ended its efforts. Similarly, the ability of great powers to impose economic sanctions may render nuclear pursuit unbearably costly for states that are vulnerable to such leverage. Further, the act of nuclear pursuit itself may provoke preventive strikes and wars (Fuhrmann and Kreps 2010, Debs and Monteiro 2016, Bas and Coe 2016), which states must take into account in their decision-making.[8] Thus although the states that are most dependent on the support of

[8]Attacks on nuclear infrastructure may be specific cases of a more general form of targeting that can also take the form of economic sanctions or the withdrawal of military support, which affect not only a state's nuclear future but also its military capabilities as a whole.

great power patrons may also have the greatest desire to develop nuclear weapons technology, this very level of dependence itself can allow great powers to prevent them from doing so. As in Leeds's (2003) work on alliances, if the smaller state's power has increased over the course of the relationship, making it less dependent, it may find that proliferation is more appealing as a result of its increased ability to withstand sanctioning efforts by its more powerful ally.

Work on the effects of sanctions has found a selection effect causing the efficacy of economic sanctions to be understated in earlier literature. Because the expected success of sanctions influences the decision to use them (Smith 1996) and instances of economic coercion often end before the threatened sanctions are actually imposed (Drezner 2003), their successes are often unobserved. This logic extends to nonproliferation sanctions; they may be more effective than usually credited because the *potential* for the threat of sanctions by great powers is enough to deter militarily or economically dependent states from nuclear pursuit (Miller 2014). In the model in the following section, this level of dependence emerges in the magnitude of the costs that patron is capable of imposing through sanctions, which in turn affects both an adversary's incentives to attack and a proliferator's likelihood of prevailing in a conflict.

When states do begin proliferation attempts, great powers can respond in a variety of ways. They can attempt to punish by imposing sanctions, either economically or by withdrawing military support, but they can also assist in this endeavor by providing economic or technical assistance in the process.[9] Debs and Monteiro (2016) refer to these as "carrot" and "stick" responses. For instance, the United States pressured South Korea to abandon its nuclear weapons program in the 1970s with threats of troop withdrawals (Choi and Park 2008), but France actively provided nuclear assistance to Israel from 1959-1965 (Kroenig 2009). I consider attempts to dissuade proliferation instances of sanctioning, while attempts to encourage proliferation are considered assistance. Both sanctioning and assistance can take military, economic, or diplomatic forms. In this analysis I focus on sanctioning rather than on assistance, but they are two sides of the same coin. Pursuing nuclear

[9]See Kroenig (2009) for a discussion of states providing sensitive nuclear assistance to others

weapons may therefore also not be an option for states that rely heavily on the support of a great power if they are aware that to do so would result in the imposition of unbearably high costs.

In some instances, however, a great power may not be able to exert enough pressure on a protégé to prevent it from building nuclear weapons, even if the great power wishes to do so. Therefore, it may be impossible to deter some states with an incredible security commitment and a high enough ability to withstand such attempts at leverage, who will acquire nuclear technology despite the efforts of great powers. France, for instance, successfully developed its own working nuclear weapon despite opposition from the US during the process. I assume here that sanctioning affects the military capability of the proliferating state; even if such sanctions are economic rather than military, states under economic pressure maintain their military strength at the cost of some tradeoff elsewhere.[10]

In addition to withstanding military or economic sanctions from a great power, autonomy also encompasses the ability to survive preventive military strikes designed to stymie nuclear weapons acquisition. Fuhrmann and Kreps (2010) examine instances of targeting nuclear weapons programs and conclude that if a state's nuclear acquisition poses a high security threat to another, the threatened state will be willing to incur significant costs to militarily derail the proliferation attempt. Historically, Israel has launched such preventive strikes against both Syria (Operation Orchard) and Iraq (Operation Opera) under the Begin Doctrine. Consistent with the Debs and Monteiro (2016) model in which great power protection can provide some cover from such attacks and thus allow proliferation efforts to proceed, the ability to withstand such preventive strikes is a part of the autonomy required to successfully develop nuclear weapons.

On the whole, the existing proliferation literature tends to take the proliferating states, the great powers with which they interact, or both as homogeneous, examining either why some states would want to pursue nuclear weapons or why other states would want to prevent them

[10]Likewise, while nuclear assistance may not directly increase military strength, it can free up resources in the form of research and development costs that can instead be funneled into military budgets.

from doing so. Without considering the strategic interactions that take place based on the identity of both the would-be proliferator *and* the would-be preventer, as well as the external threat, a crucial component in the story is missing. These interactions manifest themselves in the level of external threat, the absence of credible security guarantees, and the hierarchical relationships that constrain the military and economic autonomy to pursue nuclear weapons. I argue that each of these is a necessary condition for nuclear weapons development, but no one or two alone are always sufficient. Without a significant external threat, nuclear weapons are unnecessary. With a credible security guarantee, they are often (but not always) overly costly. And without the autonomy to develop a program in the face of international opposition, the questions of external threat and credible defensive guarantees are moot.

Chapter 3

Model

I argue that states may be driven to follow a path of nuclear proliferation in an attempt to ensure their own security when they lack a credible great power commitment to defend them.[1] Great powers, meanwhile, use sanctions or otherwise withdraw support to deter such nuclear pursuit. The formal model here shows that some states can be dissuaded from building nuclear weapons by the potential for a patron to impose costly sanctions. Further, even states with a credible security commitment cannot always be prevented from building nuclear weapons; in the face of a threat, states may still opt to proliferate if the cost of sanctions is outweighed by the military boost from nuclear weapons or if proliferation can deter an attack. To these unsurprising results, I also add the finding that, even with complete information, proliferation by a subordinate state can sometimes make a great power *more* likely to intervene on the subordinate's behalf, transforming a previously incredible defensive commitment into a credible one. Therefore, some states may pursue nuclear weapons not only to provide directly for their own security but also to enhance a great power's commitment to that security. Further, a credible defensive commitment cannot be made incredible through nuclear acquisition, meaning proliferators need not fear that they will be abandoned *after* achieving nuclear status. These results show that proliferation decisions are not one-sided, but rather depend upon a state's existing relationships and position in the international system, and that such decisions can in turn alter this structure.

[1] I use the terms *proliferator*, *protégé*, *partner*, and *ally* interchangeably throughout to describe such states in their relationship to great powers.

3.1 Assumptions

I consider the external threats states face and the security guarantees they possess as strategic decisions of other actors in the international system rather than simply exogenous factors in order to build a model of nuclear proliferation. Underlying the model are some critical assumptions.

I assume that, all else equal, great powers find the military defeat of their allies more costly if those allies are nuclear-armed. The defeat of a state in possession of nuclear weapons would call into question the fate of those weapons; great powers should be unwilling to see them fall into the hands of their adversaries. Further, a nuclear state facing an imminent loss is also a risky prospect–nuclear possession carries with it the risk of a conflict escalating to levels a great power might consider unacceptable.Therefore nuclear acquisition by a protégé may increase the incentives of its patron to defend it in the event of an attack by raising the stakes; an increased cost to the patron of the protégé's military defeat or escalation to nuclear use could change a previously incredible defensive commitment into a credible one. A great power may suddenly find it within its best interest to intervene in order to prevent a military defeat or constrain its protégé's actions.

I also assume that proliferation decisions are observable by both a state's patron and its adversaries. Although states may in practice begin to develop nuclear technology in secret, there is usually some observable hint of this endeavor. In this discussion, the decision to build nuclear weapons may be considered the moment this decision becomes known by the relevant actors, whether through announcement or discovery by another state.

3.2 Setup

Consider a model with three players: a non-nuclear *Protégé* (P), a *Great Power* defender (G), and a potential *Attacker* (A). The model is set up with complete and perfect information; all actions and choices are observable by all players.

To begin, P decides to *build* or *not build* nuclear weapons, beginning down the path to proliferation (or not). If P chooses to *build*, G then imposes a level of sanctions, $s > 0$. If P does not build, s is not declared. Once P has made its building choice and G has made its sanctions choice, A chooses to *attack* or *not attack* P. If A chooses *not attack*, the game ends in either the original status quo (if P has not chosen to build nuclear weapons) or a revised, nuclear status quo (if P has chosen *build*). If A chooses to *attack*, then G chooses to *defend* or *abandon* its protégé. If G *defends*, there is a multilateral war in which P possesses or lacks nuclear capability, depending on her proliferation decision. If G *abandons*, there is a bilateral war, where P again possess or lacks nuclear weapons according to her decision. Thus there is a war, modeled as a costly lottery, at every node in which A has chosen to *attack*, after which the game ends. The resulting stage game is shown in Figure 1.

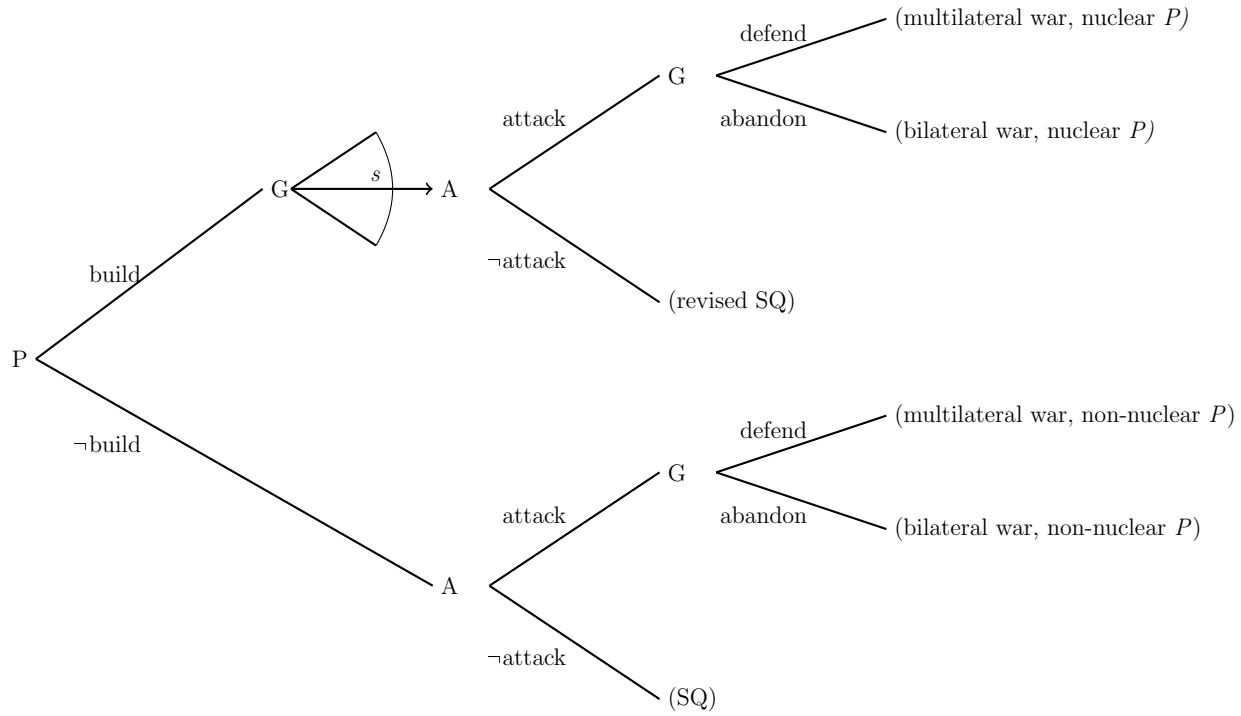

Figure 3.1: Stage Game

P wins the costly lottery of war with probability p, which is a function of its own military power m_P, its defender's power m_G, its attacker's power m_A, and the level of sanctions s imposed

on it. Formally, $p(m_i, \alpha, s) = (m_p + \alpha m_G - m_A - s)$, where $p \in (0, 1)$.The level of P's military capability increases with nuclear acquisition, such that $m_P = \underline{m}_P$ in the absence of nuclear weapons and $m_P = \overline{m}_P$ in their presence, where $\underline{m}_P < \overline{m}_P$. The parameter α takes a value of 1 if G comes to P's aid and 0 if not. Thus p takes four possible values according to P's nuclear status and G's involvement in a war, which I abbreviate: $\underline{p}$ (non-nuclear P alone), $\underline{p}_G$ (non-nuclear P with G), $\overline{p}$ (nuclear P alone), and $\overline{p}_G$ (nuclear P with G).

Note that although s can represent assistance rather than sanctioning, here I deal with the latter to represent non-proliferation preferences. I assume an upper bound, $\overline{s}$, representing the highest level of sanctioning G is actually capable of imposing, as determined by the extent of the subordinate state's dependence on the great power,[2] such that $0 \leq s \leq \overline{s}$. P begins the game in possession of some good or item, valued at 1, which A can capture through war. Thus P's value for the status quo is 1 and A's is 0. If P wins a war, it keeps the item in dispute, while its attacker A receives nothing. Conversely, if A wins, it receives the disputed item (1), while P loses it (0). This setup assumes that G does not have a stake in the issue at hand and therefore does not receive part of the value of the good, thus I denote G's value for the status quo SQ. Because I assume war is costly, any state entering a war incurs a cost c for doing so, regardless of the outcome.

If P chooses to build nuclear weapons, it pays a proliferation cost v for the process, capturing the time and resources necessary to develop such a program. Meanwhile, if P loses a war, its patron G pays some cost k for this loss. To capture the assumption that great powers prefer losses by non-nuclear subordinates to losses by nuclear subordinates, this cost is higher when P has built nuclear weapons ($k = \overline{k}$) than when it has not ($k = \underline{k}$), where $\underline{k} < \overline{k}$.

The payoff functions for each player are as follows:

[2]This upper bound indicates the degree to which a great power can reduce another state's probability of winning a war

$$U_P = \begin{cases} \overline{p}_G - v - c_P & \text{if multilateral war, nuclear P} \\ \overline{p} - v - c_P & \text{if bilateral war, nuclear P} \\ 1 - v & \text{if revised status quo} \\ \underline{p}_G - c_P & \text{if multilateral war, non-nuclear P} \\ \underline{p} - c_P & \text{if bilateral war, non-nuclear P} \\ 1 & \text{if status quo} \end{cases}$$

$$U_G = \begin{cases} SQ - c_G - \overline{k}(1 - \overline{p}_G) & \text{if multilateral war, nuclear P} \\ SQ - \overline{k}(1 - \overline{p}) & \text{if bilateral war, nuclear P} \\ SQ & \text{if revised status quo} \\ SQ - c_G - \underline{k}(1 - \underline{p}_G) & \text{if multilateral war, non-nuclear P} \\ SQ - \underline{k}(1 - \underline{p}) & \text{if bilateral war, non-nuclear P} \\ SQ & \text{if status quo} \end{cases}$$

$$U_A = \begin{cases} 1 - c_A - \overline{p}_G & \text{if multilateral war, nuclear P} \\ 1 - c_A - \overline{p} & \text{if bilateral war, nuclear P} \\ 0 & \text{if revised status quo} \\ 1 - c_A - \underline{p}_G & \text{if multilateral war, non-nuclear P} \\ 1 - c_A - \underline{p} & \text{if bilateral war, non-nuclear P} \\ 0 & \text{if status quo} \end{cases}$$

3.3 Analysis

Broadly speaking, there are three strategies great power defenders can follow, characterized by their costs for fighting on behalf of their protégé. The commitment decisions of those following two of these strategies are fixed: some defenders are reliable, while others are unreliable. A great power is considered "reliable" when its costs of fighting are sufficiently low that its defensive commitment to a protégé is always credible, regardless of the latter's nuclear status. The great power has no incentive to defect and abandon its partner. Conversely, a great power is considered "unreliable" when its costs of fighting are high enough that it is *never* expected to come to its protégé's defense, with or without the latter's nuclear possession.

A great power defender will follow the third strategy when its commitment is changeable and can be altered by its protégé's decision. The great power's costs for fighting fall into a range for which proliferation can make a previously unreliable great power decide to defend its ally. That is, although the great power would not come to its partner's aid when the latter lacks nuclear weapons, it *would* defend a nuclear-armed partner. This great power is considered "entrapped."

I therefore examine the subgame perfect equilibria when the great power follows each of these three strategies. The focus of the analysis is on those equilibria where deterrence or defense occurs — that is, where proliferation deters an attack that would have otherwise been launched, or where an attack occurs and a great power defends its ally. The first two sets of equilibria concern the great powers whose commitments are fixed, and the third set examines the case where the commitment is changeable and can be altered through proliferation.[3] The former illustrates those cases in which the motivation of drawing a defender closer is absent, and the latter includes situations in which this new mechanism is in play.

3.3.1 Fixed Great Power Credibility

In the first set of equilibria, P's decision regarding whether to build nuclear weapons does not affect G's ultimate decision to defend or abandon its partner. Where G's costs of war are high, it will never come to its ally's aid, regardless of nuclear status. Here $c_G^* \equiv \overline{k} m_G$ is the level of G's costs of war above which it will not defend P at the end of the game, regardless of whether or not the latter possesses nuclear weapons; defending P in the event of an attack will never be the best option.[4] Thus G is an unreliable defender. This threshold for unreliability set by c_G will be lower as G's costs for a loss by a nuclear P ($\overline{k}$) or the military boost P would receive from G's participation (m_G) decrease. That is, as the costs G faces for a loss by P diminish or as G's ability to influence this outcome shrinks, G's incentive to get involved also decreases, and G

[3] All equilibria considered here require that $\overline{m}_P - \underline{m}_P > s$ — the military gain from nuclear possession is greater than the sanctions imposed in their pursuit — which does not seem like an unreasonable or even unlikely constraint.

[4] A description of all cutpoints can be found in Appendix A1.

is more likely to have costs for fighting above the threshold. As these parameters increase, the reverse holds. Thus G is more likely to be unreliable as these values decrease and more likely to be reliable as they increase.

Proposition 1a shows the subgame perfect equilibrium in which G will always abandon P and nuclear proliferation by itself can deter an attack.

Proposition 1a. *When $c_G \geq c_G*$ and $1 - \overline{p} \leq c_A \leq 1 - \underline{p}$, there exists a subgame perfect equilibrium in which P builds if $\underline{p} \leq p^h$ and does not build otherwise. A does not attack if P builds nuclear weapons and attacks if she does not build. G sets $s = 0$, and Gdoes not defend its ally, whether she builds or not.*

Thus, P may choose to build nuclear weapons when A's costs of war are low enough for him to attack if she is not nuclear-capable but are high enough to avoid attacking if she is ($1 - \overline{p} \leq c_A \leq 1 - \underline{p}$). I refer to such attackers as "deterrable." Here, P will have incentives to build when $\underline{p} \leq p^h$, where $p^h \equiv 1 - v + c_P$. If her ex ante probability of winning a war alone is low enough, nuclear pursuit may be worthwhile when it can deter an attack in the first place. In such cases, the ability of nuclear weapons to deter an attack forestalls the possibility that G will pay any cost associated with its ally's engagement in a conflict, and therefore G will not attempt to prevent proliferation by P through sanctioning.

P may also choose to build nuclear weapons for her own defense. Proposition 1b shows the subgame perfect equilibrium in which nuclear weapons cannot deter an attack but may still be sought.

Proposition 1b. *When $c_G \geq c_G*$ and $c_A \leq 1 - \overline{p}$, there exists a subgame perfect equilibrium in which P builds if $\underline{p} \leq p^\gamma$ and does not build otherwise. A attacks whether P builds or not. G sets $s > s^\gamma$ if $\overline{k}(1 - \overline{p}) \geq \underline{k}(1 - \underline{p})$ and $s = 0$ otherwise, and G does not defend its ally, whether she builds or not.*

Substantively, P may also choose to build in the face of an external security threat in which an attack is imminent regardless of the status of her nuclear capability. Here, A is undeterrable when

his costs for war are low. P will choose to build against this threat when her ex ante probability of winning a war alone is low enough, or when $\underline{p} \leq p^{\gamma}$, where $p^{\gamma} \equiv \overline{p} - v$, and when the sanctions imposed by G are not overly costly. G will set sanctions at a high enough level to prevent P's proliferation if the added military boost of nuclear weapons does not outweigh risk of paying the higher cost that might be incurred when a nuclear P is involved in a conflict. This requires that $\overline{s} \leq s^{\gamma}$ where $s^{\gamma} \equiv \overline{m}_P - \underline{m}_P - v$, in essence that G is capable of setting a high enough level of sanctions to effectively prevent proliferation. If the military boost of nuclear weapons *does* outweigh the risk of paying the increased cost, or if G is unable to set sanctions sufficiently high, then she will not impose any sanctions, as doing so would serve only to diminish P's military capability and thus chances of winning the conflict.

Figure 3.2 shows the equilibrium space where D is an unreliable defender and $\overline{k}(1-\overline{p}) \leq \underline{k}(1-\underline{p})$ (that is, when G will not prevent P from building a weapon). In the bottom third of the figure, the adversary's costs of war are low enough that he is undeterrable, and so nuclear weapons can only be used for the proliferator's own defense. In the middle third, the adversary's costs are such that he will attack in the absence of nuclear weapons but not in their presence. Here, proliferation can have a deterrent effect. In the upper third, the adversary's costs are high enough that he will not attack, and there is no external threat. In this case, there is no incentive for proliferation.

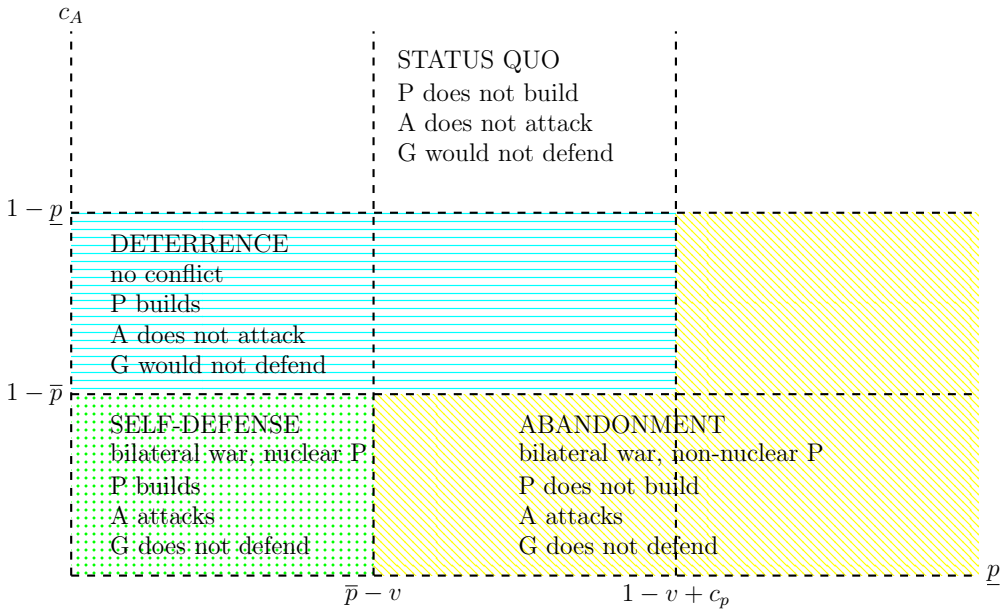

Figure 3.2: Equilibrium space in which the great power's costs of war are high, $c_G \geq c_G^*$, such that it would not defend an ally, regardless of nuclear status, and in which a great power would not impose sanctions for proliferation.

On the flip side of the coin, the second set of equilibria exists where G's costs of war are low, such that it will *always* come to its ally's aid. Here $c_G^\gamma \equiv \underline{k}m_G$ defines the threshold of the cost of war. With costs below this threshold, G will always find defending its ally to be its best option. Proposition 2a shows the subgame perfect equilibrium in which G is a reliable defender and an attack can be deterred by nuclear proliferation in conjunction with a credible defensive guarantee.

Proposition 2a. *When $c_G \leq c_G^\gamma$ and $1-\overline{p}_G \leq c_A \leq 1-\underline{p}_G$, there exists a subgame perfect equilibrium in which P builds if $\underline{p}_G \leq p^h$. A does not attack if P builds nuclear weapons and attacks if she does not build. G sets $s=0$, and G defends its ally whether she builds or not.*

Thus P again may choose to build nuclear weapons when A is deterrable, characterized as having a cost of war in the range $1-\overline{p}_G \leq c_A \leq 1-\underline{p}_G$. Here P will again build when her ex ante probability of winning is low, $\underline{p}_G \leq p^h$, where $p^h \equiv 1-v+c_P$. In this case, however, P's ex ante probability of war includes not only her own power, but also the military boost she will receive

from her patron's support. As before, when faced with a deterrable adversary, G has no incentive to attempt to prevent P's proliferation through sanctioning.

With a reliable defender in the face of imminent attack, P may still choose to build a nuclear weapon. Proposition 2b shows the subgame perfect equilibrium in which nuclear weapons cannot deter an attack yet will still be built, even with a reliable great power defender.

Proposition 2b. *When $c_G \leq c_G^{\gamma}$ and $c_A \leq 1-\overline{p}_G$, there exists a subgame perfect equilibrium in which P builds if $\underline{p}_G \leq p_G^{\gamma}$. A attacks whether or not P builds a nuclear weapon. G sets $s > s^{\gamma}$ if $\overline{k}(1-\overline{p}_G) \geq \underline{k}(1-\underline{p}_G)$ and $s = 0$ otherwise, and G defends its ally whether she builds or not.*

Here, A is undeterrable when his costs for war are low. P will choose to build against this threat when her ex ante probability of winning a war is low enough, or when $\underline{p}_G \leq p_G^{\gamma}$, where $p_G^{\gamma} \equiv \overline{p}_G - v + n_P$. As in the equilibrium where the defender is reliable and the adversary is deterrable, a proliferator's ex ante probability of war takes into account the military assistance rendered by a reliable defender. As before, if its ability to impose sanctions falls below the threshold that can deter proliferation ($\overline{s} < s^{\gamma}$, where $s\gamma \equiv \overline{m}_P - \underline{m}_P - v$), a great power will be unable to make proliferation sufficiently costly when its partner is faced with an imminent threat, regardless of whether or not the great power is planning to come to its ally's aid.

Figure 3.3 shows the equilibrium space when G is a reliable defender. In this set of equilibria, the security benefits of nuclear weapons are found strictly in their boost to the proliferator's military; the great power defender's military capability would be available to its ally whether or not she builds a weapon.

3.3.2 Changeable Commitments

In this third set of equilibria, G's decision to defend or abandon its partner depends upon P's decision to build nuclear weapons.[5] This occurs when the great power's costs of war fall into

[5]This set of equilibria requires that the more binding restraint of $\overline{m}_P - \underline{m}_P > m_G + s$ also hold. When $m_G + s > \overline{m}_P - \underline{m}_P > s$, a non-nuclear P's probability of winning a war with the aid of G becomes greater than

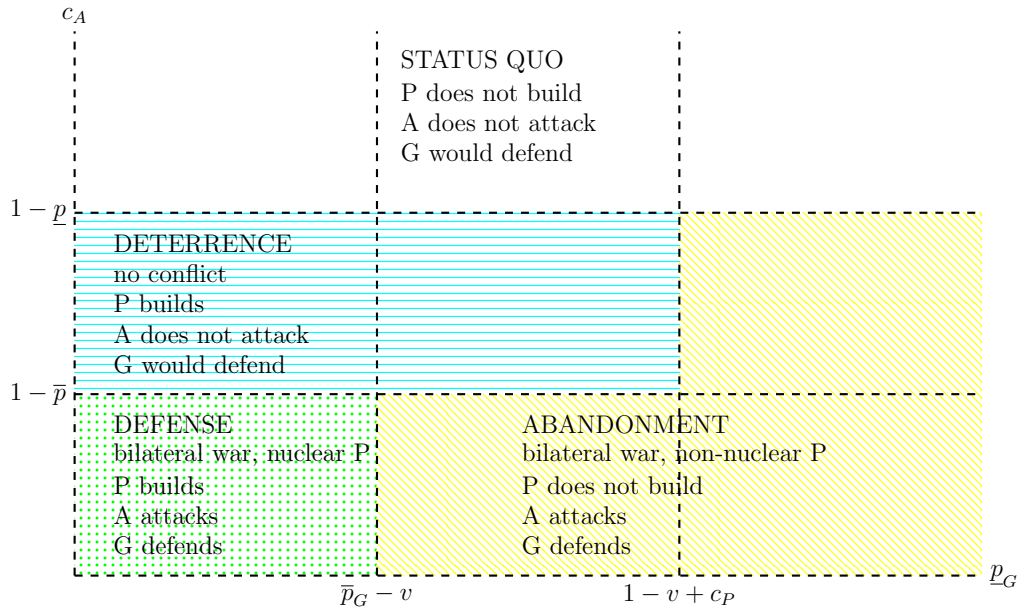

Figure 3.3: Equilibrium space in which the great power's costs of war are low, $c_G \leq c_G^{\gamma}$, such that it would always defend an ally, regardless of nuclear status, and in which a great power would not impose sanctions for proliferation.

a middle range, rendering it an entrapped defender. The additional motivation of drawing in a great power comes into play here; nuclear weapons become attractive not only for their defensive military potential, but also for their potential to increase the credibility of a patron's defensive commitment. Thus this set involves a new dimension of the security considerations involved in proliferation decisions.

In some instances this strengthened security commitment will reinforce the deterrent capacity of nuclear weapons. Proposition 3a summarizes the players' strategies in this equilibrium.

Proposition 3a. *When $c_G^{\gamma} \leq c_G \leq c_G^{*}$, and $1 - \overline{p}_G \leq c_A \leq 1 - \underline{p}$, P will build nuclear weapons if $\underline{p} \leq p^h$. A will not attack if P builds nuclear weapons and will attack if she does build them. G sets $s = 0$, and it defends if P builds nuclear weapons and does not defend if she does not build.*

the probability of a nuclear P winning unilaterally. In this case, another equilibrium emerges in which, rather than acting as a deterrent, proliferation can *provoke* an attack even as it increases a great power's credibility. I leave the analysis of this for future work.

Thus when A is deterrable, proliferation can not only deter an attack, but also reinforces G's commitment. P will build when her ex ante probability of winning a war is low enough, $\underline{p} \leq p^*$, where again $p^h \equiv 1 - v + c_P$. Here, if the proliferator were to be attacked, her patron would come to her defense. The great power again has no incentive to try to prevent proliferation in this case.

The other interesting result in this set of equilibria occurs when an adversary is undeterrable and a proliferator builds a nuclear weapon, drawing her great power ally into defending her when it would have have otherwise. This equilibrium is shown in Proposition 3b.

Proposition 3b. *When $c_G^\gamma \leq c_G \leq c_G^*$, and $c_A \leq 1 - \overline{p_G}$, P will build nuclear weapons if $\underline{p} \leq p^m$. A will attack whether or not P builds nuclear weapons. G sets $s > s^*$ if $\overline{k}(1 - \overline{p}_G) \geq \underline{k}(1 - \underline{p}_G)$ and $s = 0$ otherwise. G defends if P builds nuclear weapons and does not defend if she does not build.*

In this equilibrium, a potential proliferator may again choose to build in the face of an imminent threat from an undeterrable adversary. When her ex ante probability of winning alone against an attacker is low ($\underline{p} \leq p^m$, where $p^m \equiv \overline{p}_G - v$), proliferation increases her own military capability, but also brings the added benefit of drawing her patron into the fight on her behalf, further increasing her probability of victory. The addition of G's military capability to this calculation also increases the likelihood that the great power is unable to impose costly enough sanctions to dissuade proliferation; to prevent nuclear pursuit, such sanctions must now outweigh both the additional military boost of nuclear weapons *and* the benefit of the great power's own military.

Here, a state (P) will build nuclear weapons when sanctions are low enough, formally when $s \leq s^*$, where $s^* \equiv \overline{m}_P - \underline{m}_P + m_G - v$. This value is similar to s^γ, the threshold for s when G's commitment (or lack thereof) is fixed, but it now also includes m_G; the added benefit of a suddenly reliable partner makes nuclear pursuit more attractive. Thus the potential to make an incredible defensive commitment credible increases the sanctioning costs a proliferator is willing to pay in order to reach the goal of acquisition. The addition of G's military capability to this equation increases the likelihood that the great power is unable to impose costly enough sanctions to dissuade proliferation ($\overline{s} < s^*$).

The equilibrium space appears in Figure 3.4. The Deterrence equilibrium characterizes the area in which proliferation staves off an attack *and* draws a great power ally closer, and the Defense equilibrium illustrates the case when a great power that would not have otherwise defended its ally does so as a direct consequence of the ally's nuclear acquisition.

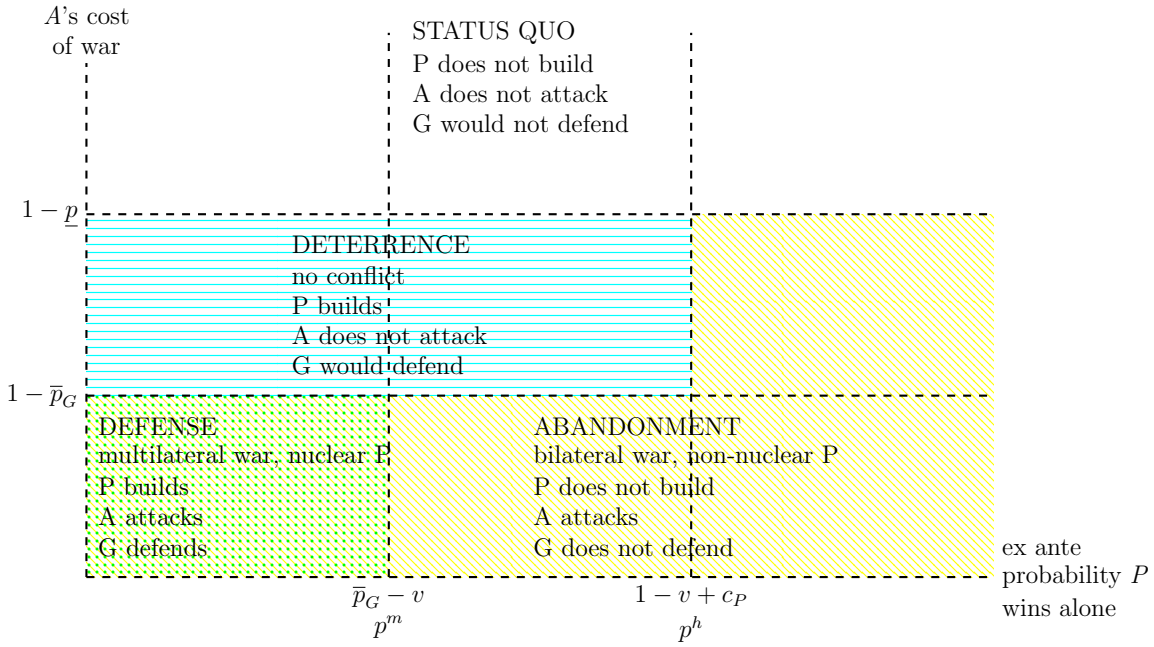

Figure 3.4: Equilibrium space in which the great power's costs of war fall into the middle range, $c_G^\gamma \leq c_G \leq c_G^*$, such that it would not defend a non-nuclear ally but *would* defend a nuclear ally, and the great power would not impose sanctions for proliferation.

As before, the ability of the great power to set a level of sanctions high enough to dissuade proliferation is crucial; a patron may be unable to prevent a protégé from pursuing nuclear weapons with the goal of securing the former's commitment. If G is unable to impose sufficiently burdensome sanctions, P may be able to exploit this by altering G's incentives to come to P's defense. Substantively, if G's costs of fighting are high enough that they outweigh its probable costs for staying out when P has only conventional weapons but low enough that staying out is unacceptably risky when a nuclear P is involved, a mutable defender's incentives can be changed through nuclear acquisition.

Chapter 4

Patterns of Proliferation and Response

The strategies of states in these equilibria show some broad patterns. First, in those cases where an adversary is undeterrable, we see the level of sanctions imposed by a great power providing the binding constraint. When G's commitment cannot be changed (it is always either reliable or unreliable), P will build when the sanctions imposed fall below the threshold s^{γ}. However, when G's commitment can be made credible through proliferation, P will build when the level of sanctions is below the higher threshold, s^{*}. The difference between these two threshold values (s^{γ} and s^{*}) is the added benefit of G's military power (m_G), which can be obtained through proliferation. Thus when P is faced with an undeterrable adversary and the potential to make G's commitment credible, it is more likely that the sanctions G is able to impose will fall below the threshold at which P finds proliferation advantageous.

Second, in cases where A will be deterred by P's nuclear possession, P's decision is predicated directly upon her ex ante probability of victory in a conflict. When she knows A will not attack if she builds nuclear weapons, she will build only if her probability of victory without them is low enough. When G is always a reliable defender, this condition is met when her chance of winning with the help of her ally is low ($\underline{p}_G \leq 1 - v + c_P$). When G is always unreliable, P's chances of winning alone ($\underline{p}$) must be below this threshold. As $\underline{p} \leq \underline{p}_G$, this constraint is easier to meet, and proliferation is more attractive. However, when G's commitment can be made credible through proliferation, it is again this lower constraint that binds. Thus when proliferation can draw a great power ally closer, a state is also more likely to build nuclear weapons when faced with a deterrable adversary than she is when her patron is always reliable. Moreover, when an adversary can be deterred through nuclear possession, a great power has no incentive to prevent

its ally from acquiring a nuclear weapon. The benefit of forestalling conflict and thus bypassing the risk of paying the associated costs is enough to allow proliferation to proceed. Thus when states believe they will bring stability, permitting nuclear weapons may become more attractive to great power allies.

The cases in which A is undeterrable, however, are defined in part by the level of sanctions imposed, as the level of costs of war below which he will always attack is $c_A \leq 1-\overline{p}$ (or $c_A \leq 1-\overline{p}_G$ with G's aid). Because $\overline{p}$ and $\overline{p}_G$ are both decreasing in s, higher levels of sanctions that weaken P's ability to fight increase this critical value, making it more likely that A's costs will be low enough to attack regardless of P's decision. Therefore, below the threshold at which they deter proliferation, great power sanctions may increase the external threat faced by their partners. Similarly, as increasing s increases the threshold for c_A below which A will attack but does not factor into $\underline{p}$ (P's ex ante probability of victory), increasing sanctions also decreases the range of values within which A can be deterred through proliferation; it becomes easier for his costs of war to be low enough that he will always attack without affecting the value above which he will not. In these cases, a great power will sometimes find it within its best interests to prevent its ally from acquiring a nuclear weapon; the associated increased risk and costs may outweigh the military benefits of possession. Thus in more volatile situations, nuclear weapons may be seen as costlier than they are worth, causing great powers to constrain their allies.

When a state's great power defensive commitment is in question and that great power also has a low level of influence economically and militarily, the subordinate state is most likely to acquire nuclear weapons. France in the aftermath of WWII provides an example of a state whose commitment from the US was in question. Following France's independent development of a nuclear arsenal over US objections, the Nixon administration's change of policy toward France's proliferation resulted in the U.S. not only dropping its protest, but covertly assisting in the process. Thus the U.S. commitment that was first questioned switched not only to a decision not to sanction France, but to active support for the proliferation process itself.

When this commitment is in question but a great power has a high level of influence over a subordinate state, the subordinate is likely to desire nuclear weapons but unlikely to be able to follow through to the point of acquiring them. Thus while South Korea in the aftermath of the Korean War was faced, like France at the end of WWII, with a US defensive commitment it had reason to doubt, its nuclear pursuit was halted because the US had enough direct military influence to use the threat of troop withdrawal in order to rein in the subordinate state. South Korea's level of dependence sowed the seeds for nuclear ambition, but it also ensured that this ambition could be thwarted.

When a great power commitment is secure and the external threats are lower, however, the costs of proliferation may be high enough that such spending is deemed unnecessary. This situation describes Japan, which has officially relied on the U.S. for its defense, including in nuclear matters, since the end of WWII. Although it is generally agreed that Japan possesses the technical capacity to develop a working bomb within a very short period of time following any decision to do so, the nature of threats in the region is currently such that it can afford not to take this step unless there is a change in its security situation. The U.S. commitment is, for the moment, sufficient.

States without a great power defensive commitment may differ from others in two important ways. First, if the absence of a great power commitment is associated with a lack of great power influence, then the ability of any state to impose costly enough sanctions to deter proliferation may also be absent. For instance, South Africa's independent development of a small nuclear arsenal during the 1970's and 1980's was likely facilitated by its position outside the sphere of influence of either the US or USSR. With neither superpower in a position to adversely affect its military strength, South Africa's decision to pursue a nuclear program was tempered only by the cost of proliferating itself.

Second, if a great power commitment is completely absent, the potential to create one may exist. Cohen (2008) argues that the absence of a great power alliance combined with the

existential fear generated its creation in the aftermath of the Holocaust sparked the beginning of Israel's nuclear program under Ben-Gurion. Thus, given Israel's size and location, the acquisition of nuclear weapons not only provided a significant boost to its defensive military capabilities, but it also drew the US into a closer relationship in which the possibility of a nuclear Israel's defeat became unacceptably costly.

Chapter 5

Conclusions

The relationship between nuclear proliferation and the reliability of great (nuclear) powers as defensive allies is multifaceted. The circumstances of the hierarchy between two states suggest that the anticipated response of a dominant power can dictate when a subordinate state will choose to engage in nuclear pursuit, and those states able to withstand the cost of proliferation can sometimes use this to bind great powers more firmly to their defense by making their own potential military defeat or escalation of conflict unacceptably costly. States with a fear of abandonment in the face of an external threat have a greater incentive to pursue nuclear weapons than others, and the level of great power influence becomes a critical factor in determining their ability to acquire them. States that are secure in their defense, however, may tend to find nuclear weapons acquisition an unnecessary and costly venture, disinclining them to undertake such pursuit unless they can acquire these weapons very cheaply or find that their effect on battlefield outcomes when faced with an undeterrable adversary will be quite large. This may be the case when states are engaged in enduring rivalries where their existence is threatened, for instance, allowing for what could be perceived as a legitimate use of the nuclear option.

Great powers, meanwhile, frequently have incentives to constrain proliferation by their subordinates. In the presence of an undeterrable adversary, the increased risks associated with nuclear possession may be great enough to make imposing sanctions to prevent acquisition an attractive option. When the hierarchy is strong enough that these sanctions can be made sufficiently costly, this course of action can prevent the spread of nuclear weapons. When a great power lacks enough leverage to dissuade proliferation, however, its best course of action may be to instead strengthen the credibility of its defensive commitment so that the benefit of its own military power substitutes

for the potential boost of a nuclear weapon. The specter of acquisition can lead to a tightening of the relationships among allies. Together the fear of abandonment in the face of an external threat and the level of great power influence, either direct or indirect, over the military power of a subordinate state in its hierarchy help illuminate some of the choices states make in the areas of proliferation and counter-proliferation.

The security commitments of the US have been shaped by its preferences over non-proliferation decisions, and this framework suggests that maintaining and even strengthening these commitments may prove crucial to preventing future weapons development. States fearing the credibility of US defensive commitments may find it worth their while to pursue nuclear weapons in order to bind the US more closely to them. Therefore, preemptively strengthening the credibility of such commitments may prove an effective form of counter-proliferation, preventing nuclear pursuit by providing, more cheaply, a commitment that would be forced upon it later regardless.

A possible extension of this argument allowing for private information in which there is uncertainty over the degree to which a subordinate state is dependent upon a great power might also allow for sanctions resulting from a miscalculation over their likely effect. Another possibility is that sanctioning undeterrable proliferators is designed to send a signal, either to the subordinate state or to the international community, of the dominant state's displeasure with the decision. Even if sanctions cannot prevent a state from building nuclear weapons, they may provide a visible sign that a great power is not complicit in the activity and does not approve of it. These suggest potential avenues for further work.

A related scenario, which lies somewhat outside the scope of this model but would be logically consistent with it, characterizes a more antagonistic relationship between two states. If a great power has no intention of intervening on another state's behalf, either because its costs of doing so are always too high or because the proliferating state is not under its protection to begin with, this would render sanctions irrelevant for its decision to defend or not. In this case, the decision to impose sanctions may instead be designed to deter other potential would-be

interveners from doing so as well. This approaches a somewhat different question with perhaps a more obvious answer, asking why a state would sanction an opponent rather than a protégé for nuclear pursuit, but it is interesting to note that the rather intuitive answer is also explained by this general model - sanctions may make a state a more appealing target directly by weakening its military capabilities, but also indirectly by reducing its attractiveness to other states as an alliance partner.

Nuclear proliferation by a subordinate state within a hierarchy can thus be motivated either by a subordinate state that is determined to build regardless of the reliability of its patron or by an unreliable patron whose subordinate is able to increase the credibility of the defensive commitment through nuclear acquisition. In the former instance, the costs to the subordinate state of proliferation and the patron's ability to impose costs are low enough and the payoffs of nuclear possession high enough that nuclear pursuit is always worthwhile. In the latter instance, the patron's sanctioning ability is low enough that in some circumstances (i.e. when the patron is unreliable), pursuit is worth bearing the costs of proliferation because the accompanying increase in the great power's reliability outweighs them.

It is important to note that neither the credibility of a defensive commitment nor the degree of an external threat are static. Both can change over time, and consequently the significance of these considerations for nuclear proliferation can also change over time. Choi and Park (2008) argue, for instance, that the changing nature of the North Korean threat and its perception by South Korea significantly influenced changes in the latter's proliferation policy over the years, making the credibility of the U.S. commitment more or less important in the process. Because these two factors are intertwined, changes in either can push states out of the status quo equilibrium and into the sequence captured in the model. While an external threat may be a necessary condition for nuclear pursuit, it is not sufficient.

Appendix

Appendix 1

1.1 Great Power Credibility

In the final move of the game, G will defend a nuclear-capable P when

$$EU_G(\text{multilateral war, nuclear P}) \geq EU_G(\text{bilateral war, nuclear P})$$

$$SQ - c_G - \overline{k}(1 - \overline{p}_G) \geq SQ - \overline{k}(1 - \overline{p}) \tag{1.1}$$

$$\overline{k}m_G \geq c_G$$

Similarly, G will defend a non-nuclear P when

$$EU_G(\text{multilateral war, non-nuclear P}) \geq EU_G(\text{bilateral war, non-nuclear P})$$

$$SQ - c_G - \underline{k}(1 - \underline{p}_G) \geq SQ - \underline{k}(1 - \underline{p}) \tag{1.2}$$

$$\underline{k}m_G \geq c_G$$

I thus define two cutpoint values for c_G, based on Equations 1.1 and 1.2. The first, $c_G^* \equiv \overline{k}m_G$, is the threshold below which G will defend a nuclear partner. The second, $c_G^\gamma \equiv \underline{k}m_G$, is the threshold below which G will defend a non-nuclear power. Note that since $\underline{k} < \overline{k}$ and m_G is strictly positive, $c_G^\gamma < c_G^*$; if G's costs of war are low enough to defend a non-nuclear partner they will necessarily also be low enough to defend a nuclear one. Thus there is no value of c_G at which G would choose to defend a non-nuclear P but would *not* choose to defend a nuclear P. Therefore

$$c_G^\gamma \equiv \underline{k}m_G \tag{1.3}$$

represents the value of c_G below which G will always defend its partner, and

$$c_G^* \equiv \overline{k}m_G \tag{1.4}$$

is the value above which G will never defend.

There is, however, a range of values of c_G for which proliferation can make a previously unreliable great power decide to defend its ally. Thus

$$c_G^{\gamma} \leq c_G \leq c_G^* \tag{1.5}$$

defines the range in which G will defend P if and only if P chooses to build nuclear weapons.

1.2 Propositions

1.2.1 Unreliable Great Powers

Proof of Propositions 1a and 1b. As demonstrated in Equation 1.4, G will never defend P when $c_G > c_G^*$, where $c_G^* \equiv \overline{k}c_G$. When this constraint holds (i.e. G will not defend its partner, with or without nuclear weapons), A must decide whether to attack. If P has built a nuclear weapon, A will attack when

$$EU_A(\text{bilateral war, nuclear P}) \geq EU_A(\text{revised SQ})$$

$$1 - c_A - \overline{p} \geq 0 \tag{1.6}$$

$$1 - \overline{p} \geq c_A$$

If P has not built a nuclear weapon, A will attack when

$$EU_A(\text{bilateral war, non-nuclear P}) \geq EU_A(\text{SQ})$$

$$1 - c_A - \underline{p} \geq 0 \tag{1.7}$$

$$1 - \underline{p} \geq c_A$$

P must therefore decide whether to build or not.

In Proposition 1a, where A is deterrable ($1 - \overline{p} \leq c_A \leq 1 - \underline{p}$), he will attack if P does not build but will *not* attack if she *does* build, and so P will build when

$$EU_P(\text{revised SQ}) \geq EU_P(\text{bilateral war, non-nuclear P})$$

$$1 - v \geq \underline{p} - c_P \tag{1.8}$$

$$1 - v + c_P \geq \underline{p}$$

As $\underline{p}$ is a function of the players' military power and sanctions imposed, $p(m_i, \alpha, s) = (m_p + \alpha m_G - m_A - s)$, Equation 1.8 can be rewritten

$$1 - v + c_P \geq \underline{m}_P - m_A \tag{1.9}$$

In this case the level of sanctions s does not enter into P's calculations of whether to build a weapon, and so G cannot prevent proliferation. However, it is also the case that G would not want to do so even if it could. G would have an incentive to make proliferation unacceptably costly when

$$\begin{aligned} EU_G(\text{bilateral war, non-nuclear P}) &\geq EU_G(\text{revised SQ}) \\ SQ - \underline{k}(1 - \underline{p}) &\geq SQ \\ \underline{k}\underline{p} &\geq \underline{k} \\ \underline{p} &\geq 1 \end{aligned} \tag{1.10}$$

which can never be true, as $\underline{p}$ is constrained to be $\in (0, 1)$. G would thus have no incentive to set $s > 0$.

In Proposition 1b, where A is undeterrable and will always attack ($c_A \leq 1 - \overline{p}$), P will build when

$$\begin{aligned} EU_P(\text{bilateral war, nuclear P}) &\geq EU_P(\text{bilateral war, non-nuclear P}) \\ \overline{p} - v - c_P &\geq \underline{p} - c_P \\ \overline{p} - v &\geq \underline{p} \end{aligned} \tag{1.11}$$

As $\underline{p}$ and $\overline{p}$ are functions of the players' military power and sanctions imposed, $p(m_i, \alpha, s) = (m_p + \alpha m_G - m_A - s)$, Equation 1.11 can be rewritten

$$\begin{aligned} (\overline{m}_P - m_A - s) - v &\geq (\underline{m}_P - m_A) \\ \overline{m}_P - \underline{m}_p - v &\geq s \end{aligned} \tag{1.12}$$

G must also decide whether to set sanctions high enough to prevent P's proliferation. It will do

so when

$$EU_G(\text{bilateral war, non-nuclear P}) \geq EU_G((\text{bilateral war, nuclear P})$$
$$SQ - \underline{k}(1-\underline{p}) \geq SQ - \overline{k}(1-\overline{p}) \tag{1.13}$$
$$\overline{k}(1-\overline{p}) \geq \underline{k}(1-\underline{p})$$

When this constraint is not met, or when G is incapable of setting s high enough to prevent proliferation, the imposition of sanctions would not prevent P from building a nuclear weapon and would only serve to decrease her chances of winning a conflict. In either case, G will set $s = 0$.

Additionally, if A will never attack ($c_A > 1 - \underline{p}$), P will build when

$$EU_P(\text{revised SQ}) \geq EU_P(\text{SQ})$$
$$1 - v \geq 1 \tag{1.14}$$

which can never be true.

□

1.2.2 Reliable Great Powers

Proof of Proposition 2a and 2b. As demonstrated in Equation 1.3, G will always defend its partner when $c_G \leq c_G^{\gamma}$, where $c_G^{\gamma} \equiv \underline{k}c_G$. When this constraint holds (i.e. G will defend its partner, with or without nuclear weapons), A must decide whether or not to attack. If P has built a nuclear weapon, A will attack when

$$EU_A(\text{multilateral war, nuclear P}) \geq EU_A(\text{revised SQ})$$
$$1 - c_A - \overline{p}_G \geq 0 \tag{1.15}$$
$$1 - \overline{p}_G \geq c_A$$

If P has not built a nuclear weapon, A will attack when

$$EU_A(\text{multilateral war, non-nuclear P}) \geq EU_A(\text{SQ})$$
$$1 - c_A - \underline{p}_G \geq 0 \tag{1.16}$$
$$1 - \underline{p}_G \geq c_A$$

By assumption $(\overline{m}_P - \underline{m}_P) > s$, which means $\underline{p}_G < \overline{p}_G$.

In Proposition 2a, where A is deterrable ($1 - \overline{p}_G \leq c_A \leq 1 - \underline{p}_G$), A will attack if P does not build a nuclear weapon and will not attack if she does build one. P will therefore build when

EU_P(revised SQ) $\geq EU_P$(multilateral war, non-nuclear P)

$$\begin{aligned} 1 - v &\leq \underline{p}_G - c_P \\ 1 - v + c_P &\leq \underline{p}_G \end{aligned} \tag{1.17}$$

As before, this can be rewritten in terms of military capabilities as

$$1 - v + c_P \leq \underline{m}_P + m_G - m_A \tag{1.18}$$

As with an unreliable great power protector, the level of sanctions s does not enter into P's decision, and so G again cannot prevent proliferation. Also as before, G would not wish to do so if it could. G would wish to impose sanctions when

EU_G(multilateral war, non-nuclear P) $\geq EU$(revised SQ)

$$\begin{aligned} SQ - c_G - \underline{k}(1 - \underline{p}_G) &\geq SQ \\ -\underline{k} + \underline{k}\underline{p}_G - c_G &\geq 0 \\ \underline{k}\underline{p}_G &\geq c_G + \underline{k} \\ \underline{p}_G &\geq \frac{c_G}{\underline{k}} + 1 \end{aligned} \tag{1.19}$$

As $\underline{p}_G$ is constrained to be $\in (0, 1)$ and c_G and $\underline{k}$ are both positive, this can never hold. G would again have no incentive to set $s > 0$.

In Proposition 2b, where A is undeterrable and will always attack ($c_A < 1 - \overline{p}_G$), P will build when

EU_P(multilateral war, nuclear P) $\geq EU_P$(multilateral war, non-nuclear P)

$$\begin{aligned} \overline{p}_G - v - c_P &\geq \underline{p}_G - c_P \\ \overline{p}_G - v &\geq \underline{p}_G \end{aligned} \tag{1.20}$$

As $\underline{p}_G$ and $\overline{p}_G$ are functions of the players' military power and sanctions imposed, $p(m_i, \alpha, s) = (m_p + \alpha m_G - m_A - s)$, Equation 1.20 can be rewritten

$$\begin{aligned}(\overline{m}_P + m_G - m_A - s) - v &\geq (\underline{m}_P + m_G - m_A) \\ \overline{m}_P - \underline{m}_p - v &\geq s\end{aligned} \tag{1.21}$$

G must again decide whether to set sanctions high enough to prevent P's proliferation, and it will do so when

$$EU_G(\text{multilateral war, non-nuclear P}) \geq EU_G(\text{multilateral war, nuclear P})$$

$$\begin{aligned}SQ - c_G - \underline{k}(1 - \underline{p}_G) &\geq SQ - c_G - \overline{k}(1 - \overline{p}_G) \\ \overline{k}(1 - \overline{p}_G) &\geq \underline{k}(1 - \underline{p}_G)\end{aligned} \tag{1.22}$$

When this constraint is not met, or when G is incapable of setting s high enough to prevent proliferation, the imposition of sanctions would not prevent P from building a nuclear weapon and would only serve to decrease her chances of winning a conflict. In either case, G will set $s = 0$.

Additionally, if A will never attack ($c_A > 1 - \underline{p}_G$), P will build when

$$\begin{aligned}EU_P(\text{revised SQ}) &\geq EU_P(\text{SQ}) \\ 1 - v &\geq 1\end{aligned} \tag{1.23}$$

which can never be true. □

1.2.3 Entrapped Great Powers

Proof of Proposition 3a and 3b. As demonstrated in Equation 1.5, G will sometimes defend its partner if P builds nuclear weapons and will not defend her if she does not build when $c_G^{\gamma} \leq c_G \leq c_G^*$. A must decide whether or not to attack. If P has built a nuclear weapon, A will attack when

$$EU_A(\text{multilateral war, nuclear P}) \geq EU_A(\text{revised SQ})$$

$$\begin{aligned}1 - c_A - \overline{p}_G &\geq -n_A 0 \\ 1 - \overline{p}_G &\geq c_A\end{aligned} \tag{1.24}$$

If P has not built a nuclear weapon, A will attack when

$EU_A(\text{bilateral war, non-nuclear P}) \geq EU_A(\text{SQ})$

$$\begin{aligned} 1 - c_A - \underline{p} &\geq 0 \\ 1 - \underline{p} &\geq c_A \end{aligned} \tag{1.25}$$

By assumption $(\overline{m}_P - \underline{m}_P) > m_G + s$, which means $\underline{p} < \overline{p}_G$.

In Proposition 3a, where A is deterrable ($1 - \overline{p}_G \leq c_A \leq 1 - \underline{p}$), A will attack if P does not build a nuclear weapon and will not attack if she does build one. P will therefore build when

$EU_P(\text{revised SQ}) \geq EU_P(\text{bilateral war, non-nuclear P})$

$$\begin{aligned} 1 - v &\leq \underline{p} - c_P \\ 1 - v + c_P &\leq \underline{p} \end{aligned} \tag{1.26}$$

As in the cases where G's credibility (or lack thereof) is fixed, when faced with a deterrable adversary P's decision over whether to build does not rely on the value of s, and therefore G cannot prevent her proliferation. Equation 1.26 can be rewritten as

$$1 - v + c_P \leq \underline{m}_P - m_A \tag{1.27}$$

Also as in the previous cases of a deterrable adversary, G would have no incentive to set $s > 0$ even if doing so could forestall proliferation. It would only want to do so when

$EU_G(\text{multilateral war, non-nuclear P}) \geq EU(\text{revised SQ})$

$$\begin{aligned} SQ - c_G - \underline{k}(1 - \underline{p}_G) &\geq SQ \\ -\underline{k} + \underline{k}\underline{p}_G - c_G &\geq 0 \\ \underline{k}\underline{p}_G &\geq c_G + \underline{k} \\ \underline{p}_G &\geq \frac{c_G}{\underline{k}} + 1 \end{aligned} \tag{1.28}$$

As shown above, this can never be true.

In Proposition 3b, where A is undeterrable and will always attack ($c_A < 1 - \overline{p}$), P will build when

$$\begin{aligned} EU_P(\text{multilateral war, nuclear P}) &\geq EU_P(\text{bilateral war, non-nuclear P}) \\ \overline{p}_G - v - c_P &\geq \underline{p} - c_P \\ \overline{p}_G - v &\geq \underline{p} \end{aligned} \tag{1.29}$$

This can be rewritten as

$$\begin{aligned} (\overline{m}_P + m_G - m_A - s) - v &\geq (\underline{m}_P - m_A) \\ \overline{m}_P - \underline{m}_p + m_G - v &\geq s \end{aligned} \tag{1.30}$$

which yields a higher threshold for s than in the previous cases. G will now set $s > \overline{m}_P - \underline{m}_p - + m_G - v$ and thus prevent proliferation when

$$\begin{aligned} EU_G(\text{multilateral war, non-nuclear P}) &\geq EU_G(\text{multilateral war, nuclear P}) \\ SQ - c_G - \underline{k}(1 - \underline{p}_G) &\geq SQ - c_G - \overline{k}(1 - \overline{p}_G) \\ \overline{k}(1 - \overline{p}_G) &\geq \underline{k}(1 - \underline{p}_G) \end{aligned} \tag{1.31}$$

When this constraint is not met, or when G is incapable of setting s high enough to prevent proliferation, the imposition of sanctions would not prevent P from building a nuclear weapon and would only serve to decrease her chances of winning a conflict. In either case, G will set $s = 0$.

Additionally, if A will never attack ($c_A > 1 - \underline{p}_G$), P will build when

$$\begin{aligned} EU_P(\text{revised SQ}) &\geq EU_P(\text{SQ}) \\ 1 - v &\geq 1 \end{aligned} \tag{1.32}$$

which again can never be true.

□

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Vita

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